NAVAL POSTGRADUATE SCHOOL
MONTEREY, CALIFORNIA

AMPLITUDE MODULATION

In this section various types of Amplitude Modulation (AM) signals are generated. Specifically we will be dealing with AM Suppressed Carrier (AMSC), AM with Carrier (AMWC), AM Large Carrier (AMLC).

Background: The mathmatical expression covering all the AM types mentioned above is:
$v_{AM}(t) = (v_m(t) + E_C)\cos \omega ct$ where:

$v_m(t)$ = message signal (no DC offset)
ωc = carrier frequency (rad/sec)
E_C = unmodulated carrier amplitude

The AM modulation index, m (coefficient), can be defined as: Eq.1 $m = \frac{|v_m(t)|\max}{E_C}$ in which case the mentioned cases correspond to values of m according to:

AMSC m = ∞
AMWC 1 < m < ∞
*AMLC 0 ≤ m ≤ 1

If the envelope function A(t) is defined as: Eq.2 $A(t) = v_m(t) + E_C$ then the modulation index in the (AMLC) case can be calculated by using the formula: Eq.3 $m = \frac{[A(t)]\max - [A(t)]\min}{[A(t)]\max + [A(t)]\min}$

(Eq.3 and Fig.1 will be needed in part 1)

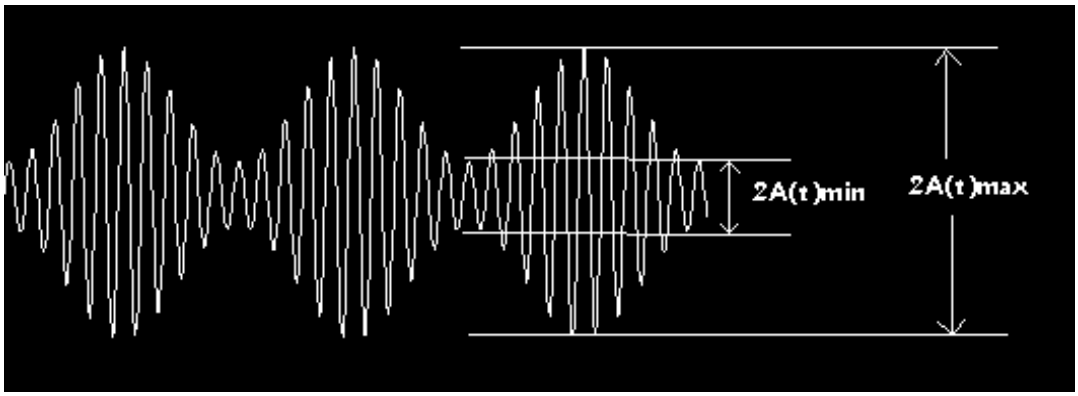

Fig. 1

[*] In some texts AMFC (Full Carrier) is used in place of AMLC.

Equipment Requirements: PC equipped with DAQ card (installed)
WaveTek Model 186 Generator
BNC cables (3), BNC tee adapter (1)

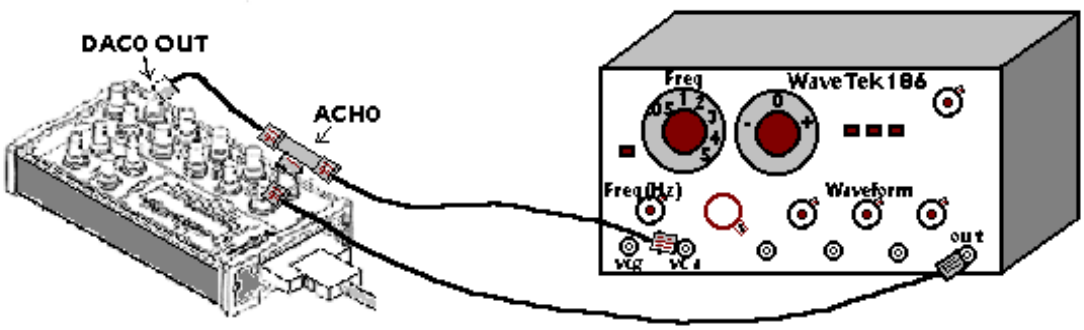

Fig.2

Connect equipment as shown in Fig. 2. Insure power to WaveTek 186 is 'ON'.

Double click VirtualBench icon.
On Instrument Select Panel (ISP) click Function Generator.
On Instrument Select Panel (ISP) click Oscilloscope.

Equipment Settings

VirtualBench Function Generator:

Frequency Range **[10k]**	Frequency Indicator **[1.000 kHz]**
Amplitude **[1 Vpk]**	Waveform **[Square]**
Duty Cycle **[50%]**	DC Offset **[0 %]**

WaveTek Model 186:

Waveform **[sine]** (fully counterclockwise (CCW))	Symmetry **[Normal]** (fully clockwise (CW))
Freq (Hz) Multiplier knob **[X10k]**	Frequency Dial **[1]**
Attenuation **[0 dB]**	Attenuation 'Variable knob' **[fully (CCW)]**
Gen Mode **[Cont]**	AM/FM/VCA Gain **[fully clockwise (CW)]**

VirtualBench Oscilloscope:

Channels **[1 & 2]**	Timebase **[200 µS/div]**
Ch1 Volts/div **[1 V]**	Ch2 Volts/div **[2 V]**
Trigger **[Auto]**	Measure **[Ch2]**

From **Edit** menu access **General Settings →Measurements** select: **[Vmax, Freq, Period, Vdc]**

Preliminary Adjustments
Set VirtualBench Function Generator and Oscilloscope in ***'Run'*** mode. (Run buttons should be intensified) You should now be observing on the Oscilloscope Ch1 a 1kHz squarewave and on Ch2 a modulating waveform. It is necessary to eliminate a DC voltage imposed on the 1kHz signal introduced internally by the Model 186 generator. If neccessary adjust the '***variable knob'*** on the Model 186 generator until the modulation envelope is constant as shown in Fig. 3. **Do not adjust this knob after setting has been made.*

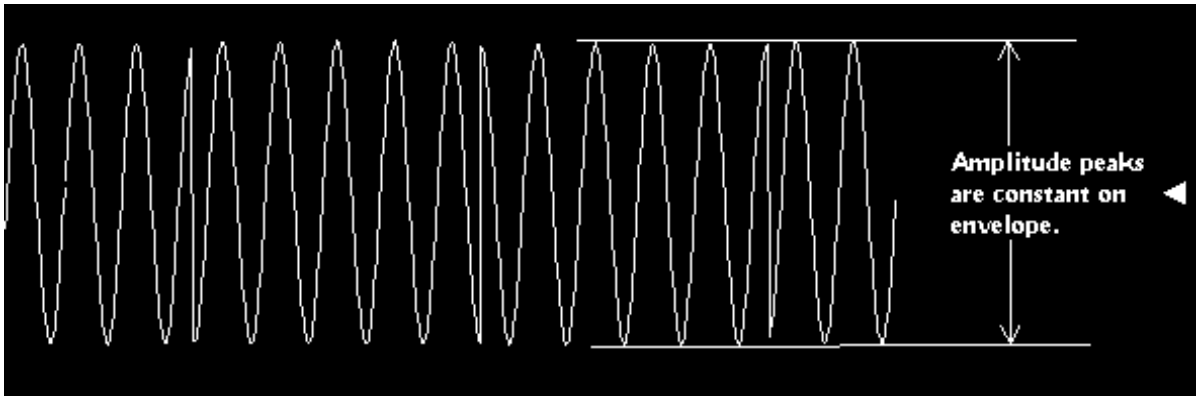

Fig. 3

Procedure
Part I Standard AM
Set the waveform function on the VirtualBench Function Generator to **'Sinewave'**.
You will now measure the amplitude value of the message signal. The amplitude value of the message signal produced by the VirtualBench Function Generator has been scaled by the Model 186 generator.
To determine the amplitude value of the message that is being modulated you must eliminate E_C.
This process is done by setting the DC value of message signal to zero. **Record** the amplitude value for (v_m) 'indicated as Vmax' on the oscilloscope (located at the bottom of oscilloscope display window).

You will now measure the Amplitude of the unmodulated carrier (E_C) by applying a pure DC voltage to the VCA input of the Model 186 Generator. To do this you must set the amplitude of the VirtualBench Function Generator to **[0 Vpk]**, and DC Offset to **[10 %]**. **Record** the value for unmodulated carrier (E_C) **'**indicated as Vmax' on the oscilloscope.

Using the equation: $m = \dfrac{|v_m(t)|\max}{E_C}$ calculate the modulation index. Print or save the oscilloscope display. Return the VirtualBench Function Generator to **[1 Vpk]**. The signal displayed on Ch2 of the Oscilloscope should be a representation of the Modulation index you calculated. Verify using **Eq.3** .
Toggle the **'RUN'** button on oscilloscope until the oscilloscope is no longer in the Run Mode (Run button will not be highlight or intensified).

On the VirtualBench Instrument Select Panel (ISP) click the Dynamic Signal Analyzer (DSA) icon. Toggle the **'RUN'** button on the (DSA) to activate the Run Mode of Analyzer (Run button should be highlighted or intensified). Make Settings to (DSA) as shown in Fig. 4.

DSA Settings

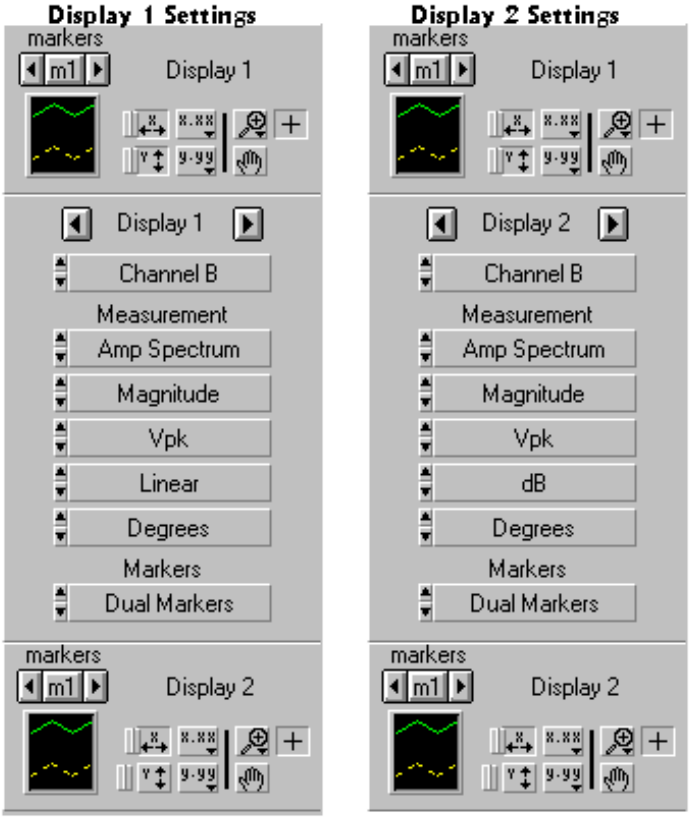

Fig. 4

From **Edit** window on (DSA) select **Acquisition** panel.
Set Sample Rate to **[40,000]** Hz, Window Type **[Flat Top]**.
Step A)
Using Markers for Display (1 & 2) record the Amplitude and Frequency values of the Fourier components. Compare with theory. To get a stable marker reading toggle **'Single'** Mode on Analyzer.
Print or Save (DSA) display.

On Oscilloscope toggle **'Run'** button to activate Oscilloscope (Run button should be highlighted).
***Note: Oscilloscope and DSA cannot run simultaneously.**
Print or save Oscilloscope display. Toggle **'Run'** to deactivate Oscilloscope.

Step B)
On the VirtualBench Function Generator select waveform **[Squarewave]**.
Repeat (Step A). *Note: It may be necessary to Fine WaveTek Gen frequency to eliminate unwanted harmonics. See Lab Tech or Instructor for assistance.*

Step C)
On the VirtualBench Function Generator select waveform **[Trianglewave]**.
Repeat (Step A).

Step D)
On the VirtualBench Function Generator select waveform **[Squarewave]**. Adjust DC Offset to **[20 %]**. Activate the **'Run'** mode of the Oscilloscope (Run button highlighted). Measure the new value of E_C by setting the Amplitude on the VirtualBench Function Generator to **[0 V]**. On the Oscilloscope record the value of E_C indicated as Vmax on the bottom portion of the Oscilloscope display. Calculate modulation index (*m*). Set the VirtualBench Function Generator Amplitude back to **[1 V]** and the Oscilloscope Volts/div to **[5 Volts/div]**.

Step E)
Using Eq.3 applied to the waveform that is present on CH2 of the Oscilloscope determine modulation index (*m*). Record the value calculated for (*m*). Print or save Oscilloscope display.
On VirtualBench Function Generator select waveform **[sinewave]**. Print or save Oscilloscope display.
Deactivate Oscilloscope **'Run'** button (Run button not highlighted).
Toggle **'Run'** button on the (DSA) to activate Analyzer. (Run button should be highlighted).
Record Frequencies and Amplitudes of the Fourier components. Compare to theory. Print or save (DSA) display.

Part II AM Suppressed Carrier

Step A)
On the VirtualBench Function Generator set DC Offset to **[0 %]**.
On the (DSA) measure and record the Frequency and Amplitude values of the Fourier Components.
Use **'Single'** mode to get a stable marker reading. Print or save (DSA) display.
Toggle **'Run'** button on Oscilloscope to activate Oscilloscope. Print or save Oscilloscope display.
Toggle **'Run'** button on the Oscilloscope to deactivate the Oscilloscope.

Step B)
On the VirtualBench Function Generator select waveform **[squarewave]**.
Repeat (Step A).

Step C)
On the VirtualBench Function Generator select waveform **[trianglewave]**.
Repeat (Step A).

Writeup

Briefly cover sketches, data and theory requested in the procedure. Prepare a table for Part 1 showing measured, predicted values, and % of error for the amplitudes and frequencies that were measured.